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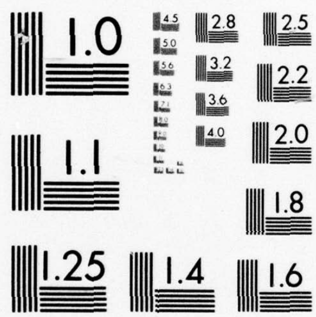

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USER'S MANUAL FOR THE DYNACYL IEMP AIR PRESSURE EFFECTS COMPUTER CODE.

IRT Corporation

P.O. Box 81087

San Diego, California 92138

(14) INTEL-RT-8141-027

(11) 14 May [redacted]76 (12) 45 p.

(9) Topical Report, [redacted] Sep[redacted]75—Jun[redacted]76.

CONTRACT No. DNA 001-76-C-0068 (15)

(10) Andrew J. Woods

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(16)

(17) B06

Prepared for

Director

DEFENSE NUCLEAR AGENCY

Washington, D. C. 20305

409 388

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DNA 4016T	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER'S MANUAL FOR THE DYNACYL IEMP AIR PRESSURE EFFECTS COMPUTER CODE		5. TYPE OF REPORT & PERIOD COVERED Topical Report for Period September 1975—June 1976
		6. PERFORMING ORG. REPORT NUMBER INTEL-RT 8141-027
7. AUTHOR(s) Andrew J. Woods		8. CONTRACT OR GRANT NUMBER(s) DNA 001-76-C-0068
9. PERFORMING ORGANIZATION NAME AND ADDRESS IRT Corporation P.O. Box 81087 San Diego, California 92138		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Subtask R99QAXEB069-03
11. CONTROLLING OFFICE NAME AND ADDRESS Director Defense Nuclear Agency Washington, D.C. 20305		12. REPORT DATE 14 May 1976
		13. NUMBER OF PAGES 50
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B323076464 R99QAXEB06903 H2590D.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

IEMP	DYNACYL Computer Code
IEMP Pressure Effects	Particle in Cell
SGEMP	Space-Charge-Limiting
Maxwell's Equations	Photo-Compton Currents
Plasma Simulation	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The DYNACYL computer code for the solution of internal electromagnetic pulse (IEMP) in cylinders containing air is documented. The code obtains time-dependent fields and currents produced by axisymmetric emissions of electrons from the ends of cylinders. Self-consistent fields and currents are calculated; migration of electrons, which are produced by air ionization, acts to reduce fields by means of a plasma conductivity. The calculation of this effect is contained in the code as a subroutine.

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20. ABSTRACT (Continued)

A brief description of the code is given, and details of utilizing it are emphasized. Considerations such as computer requirements, input and output descriptions, variable names, and a sample problem are treated in enough detail to enable the programmer with some IEMP background to meaningfully apply the code.

CONTENTS

1. INTRODUCTION

DYNACYL is a computer code used for the solution of internal electromagnetic pulse (IEMP) problems in right circular cylinders; the code includes space-charge-limiting and air-pressure effects. This class of problem occurs typically when a source of photons strikes a cylindrical body and causes electrons to be emitted from its surfaces due to photoelectric and Compton processes. These electrons produced fields which, in turn, act on the charged particles, thus altering their trajectories and affecting currents and fields in cavities. When the space-charge fields are sufficiently strong to retard the motion of electrons into the cavity, either by deflecting electrons radically to side walls or turning them around and propelling them back to the emitted surface, then the space-charge-limiting (SCL) condition has been realized. The electrons can also ionize gas molecules in cavities in the system. When the ionization density is high enough, migration of the resulting light-weight electrons away from the heavy ions toward the cylinder walls can reduce the space-charge barrier fields and permit greater penetration of primary electrons into the space, thereby, significantly changing currents and fields in the cavities. The goal of an IEMP analysis is to determine currents reaching vital components. In this regard, both space-charge-limiting and air-pressure effects may be important. DYNACYL is designed to aid in these analyses by treating both effects simultaneously.

This report contains a broad overview of the code; details on how to use it are emphasized. Detailed descriptions of the physics and modeling employed in the code are found in the references. Here, specific input card information and output descriptions are given. Computer requirements are outlined, a sample calculation is discussed, and other practical information necessary for obtaining useful information from DYNACYL is given.

DYNACYL contains as a subset its predecessor code TEDIEM-RZ. This earlier version is a quasi-static solution of the same configuration as that treated by the dynamic DYNACYL segment, but does not treat air pressure effects. It can be invoked following directions of this manual, but is otherwise left out of discussions. Complete documentation and a user's manual for this older code are available in Reference 1.

1. E. P. DePlomb and A. J. Woods, "TEDIEM-RZ and Rθ: Two-Dimensional Time-Dependent IEMP Computer Codes," DNA 3140F, March 10, 1973.

2. DYNACYL DESCRIPTION

DYNACYL solves the two-dimensional, time-dependent IEMP problem for a cylinder whose end-plates emit electrons into the interior in axisymmetric distributions. Particles representing large numbers of emitted electrons are formed and injected into the spatial grid at various energies, angles, and positions, and with various amounts of charge depending on the pulse height at the time of emission. All of the electron emission information must be specified to the code. DYNACYL automatically provides for the delay of electron emission from the back face by an amount equal to the flight time across the cavity length.

The particles of charge are moved via Newtonian equations of motion. They are converted to current densities on the spatial cell boundaries and also ionize air molecules if such are present in the cylinder. The current densities are used as source terms for Maxwell's equations, and the ionization rates are used in the plasma solution for the background gas. Both Maxwell's equations and the plasma condition are solved using finite-differencing techniques. The plasma treatment couples into the field equations by means of effective conductivity in each zone due to the secondary-electron mobility.

The details of the physics and modeling can be found in Reference 2. A useful discussion of the range of validity of the plasma formulation and other DYNACYL treatments for a specific IEMP air-pressure-effects problem are found in Reference 3. A comparison of code performance in dynamic versus quasi-static IEMP problems is found in Reference 4. It

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2. T. N. Delmer et al., "SGEMP Phenomonology and Computer Code Development," DNA 3653F, November 11, 1974.

3. D. C. Osborne, R. H. Stahl, and T. N. Delmer, "Large-Area Electron-Beam Experiments," INTEL-RT 8101-011, July 15, 1975.

4. E. P. Wenaas and A. J. Woods, "Comparisons of Quasi-Static and Fully Dynamic Solutions for Electromagnetic Field Calculations in a Cylindrical Cavity," IEEE Trans. Nucl. Sci. NS-21, December 1974.

should be noted that DYNACYL has no provision for field acceleration of secondary electrons; hence the code cannot treat the occurrence of avalanch ionization.

A flow chart summarizing the DYNACYL code cycle is shown in Figure 1. Notice that electron emission information comes from a source external to DYNACYL.

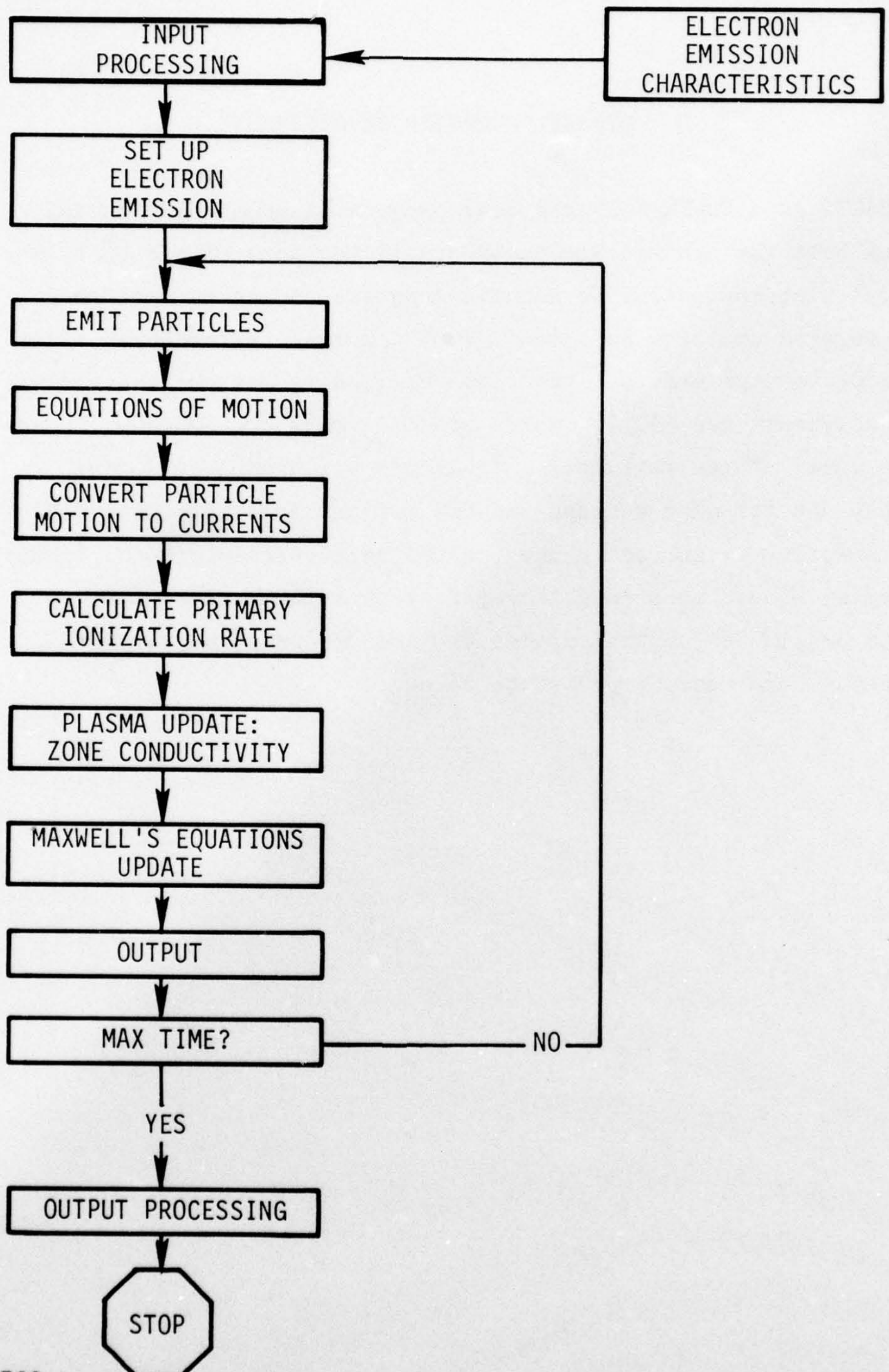

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Figure 1. DYNACYL flow chart

3. DYNACYL COMPUTER REQUIREMENTS

DYNACYL is a FORTRAN-IV computer program of about 5500 cards, including both the dynamic and quasi-static segments of the code and peripheral plot routines. No machine language coding is employed. The current version operates on the CDC 7600 computer, although an older UNIVAC 1108 version exists. The older edition is not considered here. Core requirements are 65000_{10} words of small core and $100,000_{10}$ words of large core. Three fast-access files are also required during execution, one for plot storage and two for particle information storage. The RUN compiler is currently used, although conversion to the faster FTN compiler should be straightforward at this time. Run times vary from 1 to 30 minutes central processor time, depending on problem conditions. Core must be preset to zero.

4. DESCRIPTION OF INPUTS

4.1 INTRODUCTION

Detailed descriptions of DYNACYL input cards are given in this section. The goal here is to explain how to specify the various physical and computational parameters to the code. A brief definition section is given in Table 1, in which certain terms peculiar to the DYNACYL user's manual and code outputs are defined. These descriptions are not of specific code variables, but rather of general terms employed in modeling and interpreting problems. Specific variable descriptions are found in the Input Cards and Sample Problem sections below.

Detailed discussions of card inputs are given including variable name and definition, minimum and maximum allowed values and numbers of values, defaults, locations on the cards, etc. Numerical limitations on code input and calculational variables are summarized in Table 2.

4.2 INPUT CARDS

Input card details are given in Table 3. Several conventions are used to help in quick scanning of the inputs. If the word "DEBUG" is found at the beginning of a variable description, that variable is used generally for debug purposes only and may be ignored for standard code calculations. The word "EDIT" indicates that the variable is used in choosing desired code outputs. Most of these variable types appear on the option card (card 2). Variables without the "EDIT" or "DEBUG" notation are generally the physical inputs to the problem.

The designation "card number" actually means "card type". If an array of values is being read in requiring more than one card, the cards have the same card number until the desired number of values are specified. Those input variables which are arrays and may require multiple values can be determined quickly by noting the format specification, where multiple values are indicated by a number appearing before the alphabetic character giving the variable type. Also, the descriptions tell how many variables to read in.

Table 1

DEFINITIONS OF TERMS FOUND IN THIS USER'S MANUAL AND IN DYNACYL OUTPUT

Forward emission face:	Cylinder face from which forward emission of electrons occurs. Usually taken to be bottom (z=0) face of cylinder. Emission always occurs from this face in the code. If back emission is done, opposite face emits, also.
Back of cylinder:	Face away from forward emission face (z=L)
L:	Cylinder length (cm)
Top of cylinder:	Face away from forward emission face (z=L)
Bottom of cylinder:	Forward emission face (z=0)
R:	Cylinder radius (cm)
D:	Cylinder diameter (cm)
Mini-print:	Short printout (6 lines) containing summary and plot information useful in interpreting calculational quality and code output. Can be specified at times distinct from the large 2-D prints.
2-D print:	Large printout containing spatial distributions of most physical quantities.
Primary electrons:	Designates electrons emitted into the cylinder by external source such as photo-electric emission.
Secondary electrons:	Designates electrons caused by ionization of the background gas by primary electrons. Modeled as a plasma in DYNACYL.

Table 2

MINIMUM AND MAXIMUM ALLOWED VALUES

OF DYNACYL INPUT AND CALCULATIONAL VARIABLES

Defaults are given where applicable.

Quantity	Minimum Value Allowed	Maximum Value Allowed	Default
Radial zones: (NPG)	3	20	
Axial zones: (NRGP)	3	50	
<u>Emission Specifications</u>			
Angular bins:	1	20	
Polar: (NANG)	1	20	
Azimuthal: (KOPT(10))	1	No limit except by number of particles allowed to be emitted per time step (below)	
Energy bins:	1	25 (15 for time-dependent spectra)	
Positions:	1	20	Number of radial zones
No. of different spectra: (KOPT(38))	1	10	1
Number of different particle time steps: (KOPT(12))	1	10	
Number of point pairs defining emission pulse shape: (KOPT(13))	2	41	
Number of particles emitted per time step:	0	2000	
Number of particles being followed in a given time step:	0	No limit except computer disk space	
Number of point pairs on field & current time history plots:	2	1200	

Table 3.
INPUT CARDS

Card Number	Columns (Format)	Variable	Description
1	1-78 (13A6)	TITLE	Title Card
2	1-2 (I2)	KOPT(1) (IPLOT)	EDIT: Particle trajectory information 0 No information 1 Plot sample trajectories for time of DTF nsec (see card 11) 2 Print velocities and fields acting on particles over the trajectories as well as plotting them
2	3-4 (I2)	KOPT(2)	EDIT: Print out every KOPT(2) values of the array of emission particle data (initial position, velocity, charge, etc.) if zero, code calculates value such that about 50 sample particles are printed
2	5-6 (I2)	KOPT(3)	EDIT: If >0, print out emission charge characteristics as in KOPT(2) only for 2 x KOPT(38) different times. Useful in time-dependent **spectrum** calculations for verification of emission data at different times.
2	7-8 (I2)	KOPT(4) (NESKIP)	Input emission electrons every KOPT(4) particle time steps.
2	9-10 (I2)	KOPT(5)	EDIT: If >0, calculate averages and standard deviations of certain summary quanties (see mini-print description) every KOPT(5) particle time steps
2	11-12 (I2)	KOPT(6)	DEBUG: Particle path information for sample trajectories which is printed out as the calculation unfolds.
2	13-14 (I2)	KOPT(7)	EDIT: Print fields and currents for every spatial zone away from forward emission face up to and including the KOPT(7)th **zone. See KOPT(20). DEFAULT = 1**

Table 3. (cont.)

Card Number	Columns (Format)	Variable		Description
2	15-16 (I2)	KOPT(8)	0	Emission current density uniform radially across emission face (s)
			1	Emission current density falls off radially to a value of 1/BFALL (see card 11), its value on the cylinder axis.
2	17-18 (I2)	KOPT(9)	DEBUG:	Print out information on 2-D prints in addition to standard fields and currents. ($\dot{B}$, charge per zone, potential relative to side wall, etc.)
2	19-20 (I2)	KOPT(10) (NPHI)		Number of emission electron azimuthal angular bins MIN = 1 MAX = 2000
2	21-22 (I2)	KOPT(11) (NSPD)		Number of emission electron energy bins. Cards 13 and 14 read in if KOPT(11) >0. Values of -1 and <-1 can be used where code sets mono-energetic or analytic spectra for debug purposes (see subroutine TDIMRZ) MIN NO = 1 MAX NO = 25 (15 for time dependent spectra; see KOPT(38))
2	23-24 (I2)	KOPT(12) (NTSTEP)		Number of different particle time steps (read in on cards 7 and 8) MIN = 1 MAX = 10
2	25-26 (I2)	KOPT(13) (NTPULS)		Number of point pairs used to define arbitrary emission current pulse shape read in on cards 9 and 10. MIN NO = 2 MAX NO = 41
2	27-28 (I2)	KOPT(14) (NEPTS)		Number of radial positions at which charge particles are emitted DEFAULT = No. of RADIAL ZONES MIN = 1 MAX = 20
2	29-30 (I2)	KOPT(15) (NTSKIP)	EDIT:	Print 2-D prints every KOPT(15) particle time steps. Overridden by DTPRNT (Card 6) if it is non-zero.

Table 3. (cont.)

Card Number	Columns (Format)	Variable	Description
2	31-32 (I2)	KOPT(16)	DEBUG: Print 2-D prints every particle time step up to and including step no. KOPT(16) if >0.
2	33-34 (I2)	KOPT(17)	EDIT: Number of different plot files to overlay from results of this computer run. An unlimited number of input decks can be stacked, but only up to the first 3 can be overlayed MIN = 0 MAX = 3
2	35-36 (I2)	KOPT(18)	EDIT: If >0, all 2-D prints suppressed until more than KOPT(18) particle steps have elapsed.
2	35-36 (I2)	KOPT(19)	DEBUG: If >0, positions, velocities, etc. of every particle are printed out every time step. Uses much paper.
2	39-40 (I2)	KOPT(20)	EDIT: Print fields & currents at every KOPT(20) spatial grid positions in 2-D prints. Default gives approximately 10 zones in each direction. See KOPT(7)
2	41-42 (I2)	KOPT(21)	DEBUG: Provides additional information on 2-D prints if >0
2	43-44 (I2)	KOPT(22)	EDIT: If >0, plot total currents striking bottom, side, and top on same graph with emission current wave form. All curves are divided by peak emission current.
2	45-46 (I2)	KOPT(23)	EDIT: If >0, plot peak potential on cylinder axis versus time. The position of the peak can vary with time.
2	47-48 (I2)	KOPT(24)	EDIT: If >0, plot average and peak emission electron energies versus time if the spectrum is time-varying (see KOPT(38))
2	49-50 (I2)	KOPT(25)	EDIT: If >0, plot total current collected by top of cylinder (opposite forward emission face) versus time both before and after smoothing numerical noise. Plots every time step up to number 1200. Current is divided by peak emission current.

Table 3. (cont.)

Card Number	Columns (Format)	Variable	Description
2	51-52 (I2)	KOPT(26)	EDIT: Same as KOPT(25) only for side of cylinder.
2	53-54 (I2)	KOPT(27)	EDIT: If >0, plot total current collected by top of cylinder (opposite forward emission face) at radius less than Ro and at radius greater than Ro where Ro = FCOLT * R2. R2 is cylinder radius and FCOLT is set at beginning of subroutine TDIMRZ (currently set to .67). Current is divided by peak emission current.
2	55-56 (I2)	KOPT(28)	EDIT: Same as KOPT(27) only for bottom of cylinder (forward emission face).
2	57-58 (I2)	KOPT(29)	EDIT: If >0, plot axial electric field at forward emission face (z = 0) on axis and at half cylinder radius (r/2) as well as peak radial electric field anywhere along cylinder side versus time. Position of radial field can vary with time.
2	59-60 (I2)	KOPT(30)	EDIT: If >0, plot axial electric field on axis at face opposite forward emission face (z = L) versus time
2	61-62 (I2)	KOPT(31)	EDIT: If >0, plot magnetic field at back face (z = L) at side of cylinder (r = R) versus time.
2	63-64 (I2)	KOPT(32)	EDIT: Input check-plot emission current pulse shape if >0.
2	65-66 (I2)	KOPT(33)	EDIT: If >0, plot spatial distribution of electric potential on cylinder axis at each 2-D print time
2	67-68 (I2)	KOPT(34)	EDIT: If >0, plot net charge density (ions and electrons) spatial distributions for several radial positions each 2-D print time

Table 3. (cont.)

Card Number	Columns (Format)	Variable		Description
2	60-70 (I2)	KOPT(35)	EDIT:	Print mini-print every KOPT(35) particle time steps. DEFAULT = No mini-print
2	71-72 (I2)	KOPT(36)	EDIT:	Print pressure effects quantities in 2-D prints in addition to fields and currents. Includes conductivities, conduction currents, charge densities, ionization rates
2	73-74 (I2)	KOPT(37)	DEBUG:	Allows different terms in particle equations of motion to be tested independently:
			0	E and B both act on particles
			1	E only acts on particles
			2	B only acts on particles
			3	No force due to fields acts on particles
				In all of the options above, the slowing down of particles due to ionization of the gas by the primaries still occurs.
2	75-76 (I2)	KOPT(38)		Number of different spectra representing complete emission current pulse. If more than 1 spectrum is used, code linearly interpolates in time from one spectrum to the next. If 0, randomizing routines (problem specific) are called which operate on the input distributions to randomize the energy and angular spectra (see subroutines RAMSPD and RAMIT). In that case, the number of spectra is the absolute value of KOPT(38) DEFAULT = 1 MAX = 10
2	77-78 (I2)	KOPT(39)		Quasi-Static only: **read Green's function** for fields from input unit KOPT(39)
2	79-80 (I2)	KOPT(40)		Quasi-Static only: **write Green's function** for fields to unit KOPT(40)

Table 3. (cont.)

Card Number	Columns (Format)	Variable	Description
3	17-25 (E9)	PATM	Gas pressure in cylinder in atm. Also used to flag quasi-static calculations which can be done for vacuum only. Set to -1.E-20 to indicate quasi-static.
3	26-34 (E9)	R2	Cylinder radius (cm)
3	44-52	Z2	Cylinder length (cm)
3	53-61 (E9)	NRGP	No. of spatial zones in radial direction
3	62-70	NPG	Number of spatial zones in axial direction
3	71-79 (E9)	NANG	Number of polar angular bins for emission current. If >0, code reads in angular distribution on cards 15 and 16 with NANG bins. If <0, code set cosine θ (measured from surface normal) angular distribution with NANG bins and cards 15 and 16 are not read in. If <-100, code sets isotropic angular distribution with NANG + 100 bins and cards 14 and 15 are not read in.
4	1-40 (I1)	LRATIO	Determines radial zoning in quasi-static case. Read in one LRATIO value for each radial zone. The cylinder radius is sub-divided into minimum increments equal to the radius divided by the sum of the LRATIO values. The radial zones are then the product of the individual LRATIOs times the minimum increment. Permits rapid particle finding. Read in as blank in dynamic calculations (PATM $\geq$ 0).
5	1-40 (I1)	LZRAT	Same as card 4 only for axial zones
6	17-25 (E9)	TMAX	Maximum simulation time (nsec)

Table 3. (cont.)

Card Number	Columns (Format)	Variable	Description
6	26-34 (E9)	BAKEMT	Back emission fraction. If >0, code emits particles from back face of cylinder (Z = L) with same spectrum and pulse shape as forward emission. Peak emission current density equals BAKEMT times peak forward emission current density (card 11). Back emission is delayed by photon flight time to back face.
6	35-43 (E9)	SIDEMT	**Fractional emission from side of cylinder. Not operational.**
6	44-52 (E9)	REFQ	Charge reflection fraction for electron back-scattering simulation. Not checked out thouroughly. If 0, no backscattering occurs.
6	53-61 (E9)	FINJEK	Emission current radial extent is from 0 to FINJEK x cylinder radius. DEFAULT = 1. **See BFALL (card 11)**
6	62-70 (E9)	DTPRNT	Print out 2-D prints every DTPRNT nsec if >0. Overrides KOPT(15).
7	17-70 (7E9)	TSTEP	Time range edges in nsec over which particle time step is constant and defined by DTSTEP (card 8). ie: particle time **defined by DTSTEP (card 8), ie, particle time step = DTSTEP (I) for TSTEP (I) $\leq$ TIME $\leq$ TSTEP (I + 1). Read in KOPT (12) values. First one must be zero. TSTEP (KOPT (12) + 1) set to** MIN NO = 0 MAX NO = 10
8	17-70 (7E9)	DTSTEP	Particle time steps in nsec. See card 7 above. If DTSTEP (1) = 0., code sets particle time step so an average-energy particle traverses one axial zone per particle time step. If DTSTEP(1) = -1., code makes sure time step is at least **less than or equal to 1/5 emission current pulse rise time.**

Table 3. (cont.)

Card Number	Columns (Format)	Variable		Description
9	17-70 (7E9)	TPULSE		Times at which emission current pulse defined (see card 10). Code linearly interpolates between values for emission current level. Read in KOPT(13) values. MIN NO = 2 MAX NO = 41
10	17-70 (7E9)	PULSE		Relative emission current pulse heights at times defined by TPULSE (card 9). Read in KOPT(13) values. Code shuts off pulse immediately after last value of TPULSE. MIN NO = 2 MAX NO = 41
11	17-25 (E9)	NTOT		If >0., number of electrons/cm^2 emitted at axis over entire emission current pulse. See BFALL if radial variation of emission current desired. Either NTOT or JPEAK must be input.
11	26-34 (E9)	JPEAK		If >0., peak emission current density in amp/cm^2 at axis of forward face. If zero, calculated from NTOT above. Either JPEAK or NTOT must be input. See BFALL if radial fall-off of emission current desired.
11	35-43 (E9)	DTF	EDIT:	Time interval in nsec over which sample particle trajectories are plotted (see KOPT(1)). Particles are plotted for DTF nsec, then a new batch is tagged and followed for the next DTF nsec throughout the entire problem. DEFAULT = average energy particle time to transit the cavity assuming no SCL
11	44-52 (E9)	BFALL		Emission current radial fall-off if KOPT(8) set to 1. Emission current falls off to a value at cylinder outer wall of 1./BFALL times its value on-axis. See also FINJEK (card 6). This option determines radial fall-off rate, but FINJEK determines extent of emission region independently.

Table 3. (cont.)

Card Number	Columns (Format)	Variable	Description
12	17-70 (7E9)	TSPECT	Read in only if KOPT(38) >1 for time-dependent emission current spectra. These are the times in nsec corresponding to the input spectra on cards 13 and 14. Each set of cards 13 and 14 corresponds to one value of TSPECT. For mono-energetic, time-varying emission currents, replace cards 13 and 14 with a card(s) (16X, 7E9) on which emission electron energies in kev are specified corresponding to the times on card 12. DEFAULT = 0 MAX NO = 10
13	1-80 (8E10)	EEDGE	Emission electron spectrum energy bin edges in kev. See card 14. Read in KOPT(11) + 1 values if KOPT (11) > 0.
14	1-80 (8E10)	HELN	Emission electron spectrum relative no. of electrons per unit energy in energy bins defined by card 13. Read in KOPT(11) values if KOPT (11) > 0. For time-dependent spectra, KOPT (38) pairs of cards 13 and 14 are read in.
15	1-80 (8E10)	ANGEDG	Emission electron angular distribution bin edges in degrees. Measured from surface normal. Read in NANG + 1 values (see card 3) if NANG >0, otherwise omit.
16	1-80 (8E10)	NTHETA	Emission electron angular distribution relative number of electrons per unit solid angle in bins defined by card 15. Read in NANG value if NANG > 0, otherwise omit (see card 3).

5. SAMPLE PROBLEM

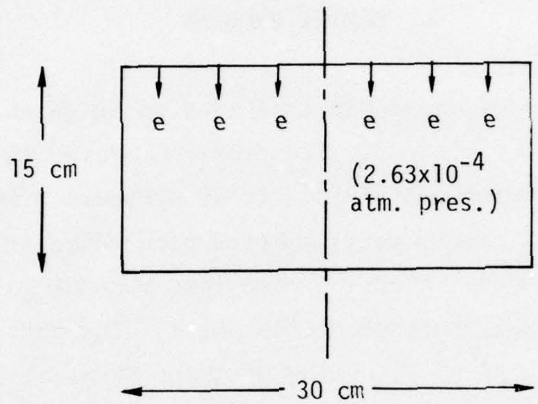
A sample problem is described in this section in which code inputs and selected outputs are explained. The problem modeled is a cylinder 15 cm long by 30 cm diameter containing air at pressure 2.63×10^{-4} atm (200 µm Hg). A pulse of electrons is emitted perpendicularly and uniformly from one end of the cylinder. Electron energies, monoenergetic at any instant, change continuously throughout the pulse. The peak density of the emission pulse is 11.6 amp/cm^2 occurring at about 50 nsec, while the peak emission electron energy is 180 keV occurring at about 6 nsec. The emission current density and energy are such that substantial space-charge-limiting would be expected if the cylinder were evacuated; instead, air at 200 µm pressure provides enough ionization under these conditions to effectively cancel the fields, resulting in almost no deflection of electron paths.

Numerically, the problem was modeled by breaking the cylinder into 5 axial and 5 radial zones, employing a particle time step of 0.2 nsec. The code calculates a light time step based on the minimun zone size. Particles were emitted from 15 radial positions. The arbitrary emission current pulse-time history and energy-versus-time curves were modeled with 9 and 10 point pairs, respectively. Mini-prints were requested every 2 nsec and spatial prints every 5 nsec. Most of the available plot options for time histories were requested.

The numerics and modeling employed here should not be taken as representative, especially the small number of spatial zones and the straight-in primary electron emission. These conditions simply provided a convenient sample problem.

5.1 SAMPLE PROBLEM INPUT CARDS

The input cards necessary for the sample problem described above are shown in Figure 2. Notice the comments at the beginnings of the data cards. These are for the programmer's convenience and are not required by the code.




```
KAMAN COMPARISON PROBLEM 200 MICRONS
 1     1     1  10 1 1 1101525    1      1       1              1 1 1      10 1 1+9
PAR2RLZ2NRNPNANG2.6300E-415.      0.           15.       5.         5.         1.


TMAXBESERQFINJ   71.9      0.        0.        0.        0.        0.
TSTEP            0.
DTSTEP           .20
TPULSE           0.        6.        12.       20.       40.       48.       54.
TPULSE           60.       66.       76.
PULSE            0.        .45       .62       1.30      4.00      5.4       5.4
PULSE            4.9       3.0       .4
NTOTJPEAKDTFBFAL 0.        11.6      0.
TENG             0.        4.        6.        18.       28.       40.       52.
TENG             56.       62.       72.
ENGY             0.        120.      180.      110.      100.      65.       25.
ENGY             6.5       3.0       1.0
0.        0.03
1.
```

Figure 2. Sample problem inputs for cylinder 15 cm long by 30 cm diameter at pressure of 2.63×10^{-4} atm. A time-dependent energy spectrum is specified.

5.2 SAMPLE PROBLEM OUTPUT

Selected code outputs essential for interpreting calculations are given in this section. In particular, the emission particle characteristics, the mini-print, and the spatial print are described fully. Definitions of the plot titles are also given in the glossary in Section 5.3.

The sample particle emission printout is given in Figure 3. This printout lists information pertaining to sample particles which represent large numbers of emission electrons. Initial positions, velocities, etc., are given. In cases where time-dependent spectra are being calculated, this printout can be specified at various times to check particle emission against input quantities [see KOPT(3), card 2]. Variable names are defined in the glossary (Table 4). The sample mini-print is found in Figure 4.

The sample spatial print is shown in Figure 5 for a time of 5 nsec. Electric fields have already been substantially dissipated at this time by large conductivity currents due to secondary electron migration (drift). The primary-electron radial current density is zero because the electrons were injected straight into the cavity and also because the magnetic field was not permitted to influence electron motion [KOPT(37) = 1].

PARTICLE EMISSION CHARACTERISTICS

TE,FT,TEB 1.4504E-05 2.7778E-03 0.

I	Z	R	THETA	PHI	ENERGY	Q	VZ	VR	VPHI	VMAG	LPHI	
1	-1.5000E+00	5.0000E-01	1.5000E-02	-0.	6.0300E-03	2.0246E-11	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-6.8745E-16	1
2	-1.5000E+00	1.5000E+00	1.5000E-02	-0.	6.0300E-03	6.0737E-11	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-6.1870E-15	2
3	-1.5000E+00	2.5000E+00	1.5000E-02	-0.	6.0300E-03	1.0123E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-1.7186E-14	3
4	-1.5000E+00	3.5000E+00	1.5000E-02	-0.	6.0300E-03	1.4172E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-3.3685E-14	4
5	-1.5000E+00	4.5000E+00	1.5000E-02	-0.	6.0300E-03	1.8221E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-5.5683E-14	5
6	-1.5000E+00	5.5000E+00	1.5000E-02	-0.	6.0300E-03	2.2270E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-8.3181E-14	6
7	-1.5000E+00	6.5000E+00	1.5000E-02	-0.	6.0300E-03	2.6320E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-1.1618E-13	7
8	-1.5000E+00	7.5000E+00	1.5000E-02	-0.	6.0300E-03	3.0369E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-1.5468E-13	8
9	-1.5000E+00	8.5000E+00	1.5000E-02	-0.	6.0300E-03	3.4418E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-1.9867E-13	9
10	-1.5000E+00	9.5000E+00	1.5000E-02	-0.	6.0300E-03	3.8467E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-2.4817E-13	10
11	-1.5000E+00	1.0500E+01	1.5000E-02	-0.	6.0300E-03	4.2516E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-3.0316E-13	11
12	-1.5000E+00	1.1500E+01	1.5000E-02	-0.	6.0300E-03	4.6565E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-3.6366E-13	12
13	-1.5000E+00	1.2500E+01	1.5000E-02	-0.	6.0300E-03	5.0615E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-4.2965E-13	13
14	-1.5000E+00	1.3500E+01	1.5000E-02	-0.	6.0300E-03	5.4664E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-5.0115E-13	14
15	-1.5000E+00	1.4500E+01	1.5000E-02	-0.	6.0300E-03	5.8713E-10	4.5654E+07	-5.1639E-04	1.1952E+04	4.5654E+07	-5.7814E-13	15

Figure 3. DYNACYL particle emission characteristics printout example. Characteristics are given for a time of .2 nsec or at end of the first time step.

```
ITIME,T,JNOW,QINJEK,VMAX,SUMFJ,HST     20  4,000E+00 6,444E-01 9,566E-07-1,351E+03 7,500E-02 0.         0.         7,500E-02   105
INJEK,NLVTOT,NR2,NZ1,NZ2   ,   300   195     0     0     SOQR2,QZ1,QZ2,QLEAVE    0.          0.          4,7375E-07 5,6775E-07
IBOT,SIDE,TOP   0.          0.               6,1497E+02EZMAX,ERMIN,BMAX,BHOT,EZBAR   , -2,42E+04 -1,73E+04 -5,19E+00 -5,28E+00  1,76E+04
NF1,QR1,IPSTOP,ISTOPT,QSTOP,QSTOPT,QINSYD,QDIF     0 0,          0     0 0,          0,          4,1105E-07 5,3982E-02
EFARPT,T  1,2060E-01 1.2060E-01
IBOT,TOPIN  0.          2,7532E+02
```

Figure 4. DYNACYL mini-print example for time of 4 nsec.

```
 TIME = 5.000      STEP NO. =  25      NO. OF PARTICLES =   90     I EMITTED=  5.694E+02      NR1=    0      NR2=    0
 NO. LEAVING =   15          NZ1=     0   NZ2=     15     JPEAK= 1.160E+01 AMP/CM**2      JNOW= 8.056E-01 AMP/CM**2
NINJER=     375 NLVTOT=      285 AVERAGE CHARGE DENSITY IS  4.039E-11 COUL/CM**3   PLASMA OSCILLATION PERIOD IS  7.010E+00 NS

    QINJER     QLEAVE     QINSYD     QDIF          EQ     ITOP       IBOT       ISIDE      JTOP       JBOT       JSIDE
 1.480E-06 1.074E-06 4.282E-07 5.182E-02 5.694E+02 4.328E+02 0.         0.         6.122E-01 0.         0.
   QZ2        QZ1        QR2        FQTOP      FQBOT      FQSIDE     FJTOP      FJBOT      FJSIDE     SUMFQ      SUMFJ      TE
 8.655E-07 0.         0.         5.846E-01 0.         0.         5.278E-02 0.         0.         8.738E-01 5.278E-02 3.626E-04


 MAXIMUM NUMBER OF PARTICLES IN CYLINDER AT ANY ONE TIME SO FAR IS         210

RG          0.         3.000E+00 6.000E+00 9.000E+00 1.200E+01

QOUTT
       1.221E-09 1.223E-09 1.221E-09 1.120E-09 1.177E-09
JOUTT
       6.122E-01 6.122E-01 6.122E-01 6.122E-01 6.122E-01
QOUTB
       0.         0.         0.         0.         0.
JOUTB
       0.         0.         0.         0.         0.

Z
          0.         3.000E+00 6.000E+00 9.000E+00 1.200E+01 1.500E+01

QOUTS
       0.         0.         0.         0.         0.
JOUTS       0.         0.         0.         0.         0.

    QZ1P       QZ2P       QR2P       QLEAVP
 0.         8.322E-07 0.         4.794E-06


                              BDOT  (GAUSS/NSEC)

    R         0.            3.00000E+00 6.00000E+00 9.00000E+00 1.20000E+01 1.50000E+01

      Z
 1.2000E+01 -4.486E-01  -8.614E-01  -1.040E+00  -1.200E+00  -1.684E+00  -1.933E+00
 9.0000E+00 -1.042E-01  -4.300E-01  -1.185E+00  -1.265E+00  -1.074E+00  -9.795E-01
 6.0000E+00 -5.442E-01  -9.121E-02  -1.349E+00  -1.118E+00  -1.243E+00  -1.305E+00
 3.0000E+00 -3.258E-01  -2.818E-01  -6.365E-01  -1.523E+00  -1.112E+00  -9.058E-01
 0.         -2.593E-01  -2.005E-01  -1.168E+00  -1.157E+00  -1.142E+00  -1.134E+00


NO. OF PARTICLES IN EACH ZONE

    R         0.            3.00000E+00 6.00000E+00 9.00000E+00 1.20000E+01

      Z
 1.2000E+01  3.000E+00   3.000E+00   3.000E+00   3.000E+00   3.000E+00
 9.0000E+00  3.000E+00   3.000E+00   3.000E+00   3.000E+00   3.000E+00
 6.0000E+00  3.000E+00   3.000E+00   3.000E+00   3.000E+00   3.000E+00
 3.0000E+00  0.          0.          0.          0.          0.
 0.          3.000E+00   3.000E+00   3.000E+00   3.000E+00   3.000E+00
```

Figure 5. DYNACYL spatial print example. This printout is also referred to as a "2-D print" elsewhere in this report.

BEST AVAILABLE COPY

CHARGE (COUL)

R	0,	3,00000E+00	6,00000E+00	9,00000E+00	1,20000E+01
Z					
1,2000E+01	4,009E-09	1,203E-08	2,004E-08	2,806E-08	3,608E-08
9,0000E+00	4,191E-09	1,257E-08	2,095E-08	2,934E-08	3,772E-08
6,0000E+00	4,373E-09	1,312E-08	2,187E-08	3,061E-08	3,936E-08
3,0000E+00	0,	0,	0,	0,	0,
0,	4,555E-09	1,367E-08	2,278E-08	3,189E-08	4,100E-08

POTENTIAL REL, TO Z=L (VOLTS)

R	0,	3,00000E+00	6,00000E+00	9,00000E+00	1,20000E+01
Z					
1,2000E+01	8,099E+01	2,319E+00	8,361E+01	2,928E+02	2,304E+02
9,0000E+00	-3,204E+02	-3,740E+02	-2,306E+02	1,419E+02	2,005E+02
6,0000E+00	-8,219E+02	-7,611E+02	-6,871E+02	-2,237E+02	1,168E+02
3,0000E+00	-1,324E+03	-1,140E+03	-1,159E+03	-6,196E+02	-1,062E+02
0,	-1,802E+03	-1,526E+03	-1,589E+03	-1,065E+03	-4,563E+02

CYCLE = 25 TIME =5,00000E-09 DTN2 =5,00000E-11 DTN =5,00000E-11

***** ER *****

R	1,50000E-02	4,50000E-02	7,50000E-02	1,05000E-01	1,35000E-01
Z					
1,3500E-01	-8,472E+02	-4,876E+02	-1,030E+03	-2,216E+03	-8,365E+03
1,0500E-01	-7,748E+02	3,461E+03	6,298E+03	-8,323E+03	-1,333E+04
7,5000E-02	-1,466E+02	1,481E+03	5,412E+03	-2,928E+03	-1,451E+04
4,5000E-02	-2,844E+02	9,888E+02	1,728E+03	3,838E+03	-1,199E+04
1,5000E-02	2,716E+02	8,926E+02	2,199E+02	1,347E+03	-4,394E+03

***** JR *****

R	1,50000E-02	4,50000E-02	7,50000E-02	1,05000E-01	1,35000E-01
Z					
1,3500E-01	0,	0,	0,	0,	0.
1,0500E-01	0,	0,	0,	0,	0.
7,5000E-02	0,	0,	0,	0,	0,
4,5000E-02	0,	0,	0,	0,	0,
1,5000E-02	0,	0,	0,	0,	0,

***** CHARGE DENSITY *****

R	1,50000E-02	4,50000E-02	7,50000E-02	1,05000E-01	1,35000E-01
Z					
1,3500E-01	-5,704E-05	-4,210E-05	-4,187E-05	-4,169E-05	-2,933E-05
1,0500E-01	-5,737E-05	-4,221E-05	-4,173E-05	-4,156E-05	-2,884E-05
7,5000E-02	-5,681E-05	-4,185E-05	-4,130E-05	-4,114E-05	-2,829E-05
4,5000E-02	-5,556E-05	-4,101E-05	-4,085E-05	-4,053E-05	-2,762E-05
1,5000E-02	-5,379E-05	-3,973E-05	-3,985E-05	-4,005E-05	-2,710E-05

Figure 5 (cont.)

```
*****  H-PHI  *****

  R        1,50000E-02 4,50000E-02 7,50000E-02 1,05000E-01 1,35000E-01

     Z
1,5000E-01 -7,858E+01  -1,776E+02  -2,952E+02  -4,118E+02  -5,222E+02
1,2000E-01 -8,226E+01  -1,849E+02  -2,956E+02  -4,086E+02  -5,297E+02
9,0000E-02 -7,959E+01  -1,791E+02  -2,949E+02  -4,116E+02  -5,252E+02
6,0000E-02 -8,437E+01  -1,724E+02  -2,971E+02  -4,076E+02  -5,280E+02
3,0000E-02 -8,329E+01  -1,724E+02  -2,862E+02  -4,111E+02  -5,299E+02
0,         -8,518E+01  -1,736E+02  -2,894E+02  -4,056E+02  -5,308E+02

 *****  EZ  *****

   R       0,          3,00000E-02 6,00000E-02 9,00000E-02 1,20000E-01 1,50000E-01

     Z
1,5000E-01 -1,731E+04  -1,225E+04  -1,195E+04  -1,583E+04  -1,569E+04   0,
1,2000E-01  1,191E+04   1,209E+04   6,379E+03  -3,691E+03   3,263E+02   0,
9,0000E-02  1,485E+04   1,299E+04   1,457E+04   1,375E+04   1,670E+03   0,
6,0000E-02  1,858E+04   1,282E+04   1,586E+04   1,061E+04   3,912E+03   0,
3,0000E-02  1,491E+04   1,241E+04   1,561E+04   1,578E+04   1,095E+04   0,
0,          1,695E+04   1,338E+04   1,305E+04   1,393E+04   1,239E+04   0,

 *****  JZ  *****

   R       0,          3,00000E-02 6,00000E-02 9,00000E-02 1,20000E-01 1,50000E-01

     Z
1,5000E-01 -1,045E+04  -7,433E+03  -7,427E+03  -7,402E+03  -7,379E+03  -3,504E+03
1,2000E-01 -1,067E+04  -7,585E+03  -7,582E+03  -7,559E+03  -7,535E+03  -3,570E+03
9,0000E-02 -1,087E+04  -7,722E+03  -7,719E+03  -7,706E+03  -7,686E+03  -3,623E+03
6,0000E-02 -1,104E+04  -7,846E+03  -7,844E+03  -7,834E+03  -7,818E+03  -3,669E+03
3,0000E-02 -1,120E+04  -7,956E+03  -7,956E+03  -7,952E+03  -7,942E+03  -3,709E+03
0,         -1,134E+04  -8,055E+03  -8,055E+03  -8,055E+03  -8,055E+03  -3,744E+03

JZ AT THE UPPER WALL

        I =              1          2          3          4          5
        R =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *          *          *          *          *
  6   1,500E-01   *-1,004E+04-7,429E+03-7,412E+03-7,389E+03-5,226E+03

 *****  JZ AT THE LOWER WALL  *****

        I =              1          2          3          4          5
        R =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *          *          *          *          *
  1   0,          *-1,089E+04-8,055E+03-8,055E+03-8,055E+03-5,660E+03

 *****  JR AT THE OUTER WALL  *****

        J =              1          2          3          4          5
        Z =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  I       R              *          *          *          *          *
  6   1,500E-01   * 0,         0,         0,         0,         0,

 *****  KR AT UPPER WALL  *****

        I =              1          2          3          4          5
        R =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *          *          *          *          *
  6   1,500E-01   *-7,858E+01-1,776E+02-2,952E+02-4,118E+02-5,222E+02

 *****  KR AT LOWER WALL  *****

        I =              1          2          3          4          5
        R =        . 1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *          *          *          *          *
  1   0,          * 8,518E+01 1,736E+02 2,894E+02 4,056E+02 5,308E+02
```

Figure 5 (cont.)

```
        KZ AT OUTER WALL

        J =            1           2           3           4           5
        Z =            1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  I       R              *           *           *           *           *
  6   1,500E-01   * 5,730E+02 5,708E+02 5,675E+02 5,685E+02 5,665E+02

*****  TOTAL CHARGES ON THE SYSTEM  *****

  INSIDE CYLINDER              UPPER WALL                LOWER WALL                OUTER WALL                SYSTEM TOTAL

    -3,931E-07                  1,620E-07                 4,583E-08                 1,853E-07                 9,317E-21

*****  UPPER WALL CHARGE DENSITY  *****

        I =            1           2           3           4           5
        R =            1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *           *           *           *           *
  6   1,500E-01   * 2,352E-06 1,804E-06 1,764E-06 1,510E-06 3,350E-06

*****  LOWER WALL CHARGE DENSITY  *****

        I =            1           2           3           4           5
        R =            1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z              *           *           *           *           *
  1   0,          * 4,342E-06 3,366E-06 2,797E-06 1,794E-06-2,753E-06

*****  OUTER WALL CHARGE DENSITY  *****

        J =            1           2           3           4           5           6
        Z =            0,          3,000E-02 6,000E-02 9,000E-02 1,200E-01 1,500E-01
  I       R              *           *           *           *           *           *
  6   1,500E-01   * 8,046E-07 1,437E-06 1,692E-06 1,810E-06 8,089E-07 0,

        ***********  PLASMA CHARACTERISTICS  ***********

*****  SIGMA-Z  *****

   R       0,          3,00000E-02 6,00000E-02 9,00000E-02 1,20000E-01 1,50000E-01

     Z
1,5000E-01  2,006E-03    2,204E-03    2,552E-03    2,070E-03    2,392E-03    0,
1,2000E-01  1,596E-03    1,819E-03    2,450E-03    3,041E-03    4,101E-03    0,
9,0000E-02  3,670E-02    4,281E-02    2,056E-03    2,213E-03    3,764E-03    0,
6,0000E-02  2,184E-03    5,970E-02    2,659E-03    6,186E-02    3,945E-03    0,
3,0000E-02  7,192E-02    8,141E-02    3,677E-03    3,503E-03    4,171E-03    0,
0,          8,266E-02    9,421E-02    9,652E-02    4,154E-03    4,354E-03    0,

*****  JZ CONDUCTIVITY  *****

        I =            1           2           3           4           5           6
        R =            0,          3,000E-02 6,000E-02 9,000E-02 1,200E-01 1,500E-01
  J       Z              *           *           *           *           *           *
  6   1,500E-01   *-3,472E+01-2,699E+01-2,812E+01-3,276E+01-3,754E+01 0,
  5   1,200E-01   * 1,900E+01 2,199E+01 1,563E+01-1,122E+01 1,338E+00 0,
  4   9,000E-02   * 5,450E+02 5,562E+02 2,996E+01 3,044E+01 6,285E+00 0,
  3   6,000E-02   * 4,059E+01 7,653E+02 4,216E+01 6,567E+02 1,543E+01 0,
  2   3,000E-02   * 1,072E+03 1,010E+03 5,739E+01 5,529E+01 4,568E+01 0,
  1   0,          * 1,401E+03 1,260E+03 1,260E+03 5,785E+01 5,393E+01 0,
```

Figure 5 (cont.)

```
*****  SIGMA-R  *****

  R        1,50000E-02 4,50000E-02 7,50000E-02 1,05000E-01 1,35000E-01

   Z

1,3500E-01  3,536E-03    3,873E-03    2,704E-03    2,150E-03    3,194E-03
1,0500E-01  1,175E-03    1,734E-03    2,319E-03    2,808E-03    3,048E-03
7,5000E-02  4,482E-02    5,742E-02    2,059E-03    2,043E-03    2,891E-03
4,5000E-02  6,083E-02    3,101E-03    3,068E-03    3,282E-03    4,396E-03
1,5000E-02  8,553E-02    1,011E-01    4,058E-03    3,922E-03    5,348E-03

*****  JR CONDUCTIVITY  *****

       I =              1          2          3          4          5
       R =         1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J      Z             *          *          *          *          *
  5   1,350E-01   *-2,995E+00-1,889E+00-2,786E+00-4,765E+00-2,672E+01
  4   1,050E-01   *-9,104E-01 6,001E+00 1,461E+01-2,338E+01-4,063E+01
  3   7,500E-02   *-6,570E+00 8.502E+01 1.114E+01-5,981E+00-4,196E+01
  2   4,500E-02   *-1.730E+01 3.066E+00 5.303E+00 1,260E+01-5,273E+01
  1   1,500E-02   * 2,323E+01 9,025E+01 8,923E-01 5,283E+00-2,349E+01

*****  IONIZATION RATES  *****

PRIMARY ELECTRON IONIZATION RATE (NO,/M**3/SEC)

       I =              1          2          3          4          5
       R =         1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J      Z             *          *          *          *          *
  5   1,350E-01   * 1,366E+23 1,365E+23 1.365E+23 1,364E+23 1,363E+23
  4   1,050E-01   * 1,410E+23 1,410E+23 1,409E+23 1,409E+23 1,408E+23
  3   7.500E-02   * 1,453E+23 1,453E+23 1,453E+23 1,453E+23 1,452E+23
  2   4,500E-02   * 0,        0,        0,        0,        0,
  1   1,500E-02   * 1,496E+23 1,496E+23 1,496E+23 1,496E+23 1,496E+23

ECONDARY IONIZATION RATE (NO,/M**3/SEC/ELECTRON)

       I =              1          2          3          4          5
       R =         1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J      Z             *          *          *          *          *
  5   1,350E-01   * 1,189E-16 2,249E-16 7,547E-15 1,217E-14 1,413E-14
  4   1,050E-01   * 2,284E-14 2,063E-14 1,661E-14 1,577E-14 2,195E-14
  3   7,500E-02   * 2,340E-14 2,334E-14 2,305E-14 1,428E-14 2,207E-14
  2   4,500E-02   * 2,424E-14 2,274E-14 2,247E-14 1,894E-14 2,089E-14
  1   1,500E-02   * 2,599E-14 2,414E-14 2,271E-14 2,027E-14 1,181E-14

*****  RHO-E  *****

       I =              1          2          3          4          5
       R =         1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J      Z             *          *          *          *          *
  5   1,350E-01   * 1,901E+14 2,162E+14 2,107E+14 1,814E+14 2,735E+14
  4   1,050E-01   * 1,112E+14 1,617E+14 2,069E+14 2,465E+14 2,880E+14
  3   7,500E-02   * 1,810E+14 2,251E+14 1,962E+14 1,749E+14 2,740E+14
  2   4,500E-02   * 2,274E+14 2,876E+14 2,881E+14 2,945E+14 3,996E+14
  1   1.500E-02   * 3.418E+14 3.885E+14 3.790E+14 3,618E+14 4,402E+14

*****  RHO-I  *****

       I =              1          2          3          4          5
       R =         1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J      Z             *          *          *          *          *
  5   1,350E-01   * 4,433E+14 4,390E+14 4,419E+14 4,104E+14 4,102E+14
  4   1,050E-01   * 4,243E+14 4,298E+14 4,425E+14 4,725E+14 4,813E+14
  3   7,500E-02   * 4,749E+14 4,934E+14 4,545E+14 4,184E+14 4,526E+14
  2   4,500E-02   * 5,286E+14 5,487E+14 5,444E+14 5,279E+14 5,626E+14
  1   1,500E-02   * 6,223E+14 6,415E+14 6,343E+14 6,083E+14 5,953E+14
```

Figure 5 (cont.)

```
*****  JZ CONDUCTIVITY AT THE UPPER WALL  *****

       I =              1          2          3          4          5

       R =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z             *          *          *          *          *
  6   1,500E-01    *-3,085E+01-2,756E+01-3,044E+01-3,515E+01-1,877E+01

*****  JZ CONDUCTIVITY AT THE LOWER WALL  *****

       I =              1          2          3          4          5
       R =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  J       Z             *          *          *          *          *
  1   0.           * 1,331E+03 1,260E+03 6,589E+02 5,589E+01 2,696E+01

*****  JR CONDUCTIVITY AT THE OUTER WALL  *****

       J =              1          2          3          4          5
       Z =          1,500E-02 4,500E-02 7,500E-02 1,050E-01 1,350E-01
  I       R             *          *          *          *          *
  6   1,500E-01    *-3,357E+01-7,559E+01-5,455E+01-4,667E+01-3,440E+01

NET CHARGE DENSITY (COUL/M**3)

   R        1,50000E-02 4,50000E-02 7,50000E-02 1,05000E-01 1,35000E-01

     Z
1,3500E-01 -6,692E-06   -1,155E-05   -1,022E-05   -1,056E-05   -2,536E-05
1,0500E-01  7,504E-07   -6,458E-06   -1,167E-05   -1,321E-05   -1,844E-05
7,5000E-02 -4,477E-06   -8,560E-06   -1,017E-05   -1,253E-05   -2,294E-05
4,5000E-02  4,826E-05    4,183E-05    4,106E-05    3,740E-05    2,612E-05
1,5000E-02 -8,763E-06   -1,318E-05   -1,279E-05   -1,420E-05   -2,886E-05


                                                    POTENTIAL REL. TO R=A     (VOLTS)

   R        0.           3,00000E+00 6,00000E+00 9,00000E+00 1,20000E+01

     Z
1,2000E+01  3,810E+02    3,860E+02    4,220E+02    4,331E+02    2,925E+02
9,0000E+00  3,723E+02    3,874E+02    4,649E+02    5,291E+02    3,842E+02
6,0000E+00  3,488E+02    3,565E+02    4,001E+02    4,664E+02    4,006E+02
3,0000E+00  2,864E+02    2,934E+02    3,148E+02    3,559E+02    3,407E+02
0.          0.           0.           0.           0.           0.
```

Figure 5 (cont.)

5.3 DYNACYL VARIABLE GLOSSARY

A glossary defining DYNACYL variables and printout headings is listed in this section. Between this glossary and the Input Cards section given previously, all of the code input variables and most of the output variables are defined. A few output variables, primarily of a debug nature, probably remain undefined, but all essential outputs are described. In addition to the "visible" code variables, many internal quantities are also found in the glossary. Thus the tabulation is useful in aiding the programmer to understand many of the essential calculational quantities of the code. Many variables tabulated will be found to pertain only to the quasi-static, or Green's function, treatment contained in DYNACYL as a subset. The programmer should keep in mind these are simply options and in no way indicate DYNACYL is limited to quasi-static situations.

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Table 4

DYNACYL VARIABLE GLOSSARY

GLOSSARY OF DYNACYL VARIABLES AND OUTPUT HEADINGS

A	RADIUS OF CYLINDER A=R2 (CM)
ANG	ANGLE BETWEEN VELOCITY OF EMITTED ELECTRONS AND INCOMING PHOTONS OR THE SURFACE NORMAL DEPENDING ON KOPT(7) (DEG.)
ASIDE	AREA OF SIDE OF CYLINDER (CM**2)
ATOP	AREA OF TOP OF CYL (CM**2)
AVERAGE CHARGE DENSITY	TOTAL PARTICLE CHARGE IN CYLINDER DIVIDED BY CYLINDER VOLUME. PLASMA CHARGE NOT INCLUDED. (COUL/CM3)
BAKEMT	BACK EMISSION CURRENT FRACTION, EXPRESSED AS FRACTION OF CURRENT EMITTED FROM FRONT FACE
BBOT	MAGNETIC FIELD AT CYLINDER SIDE WALL AT BOTTOM (FORWARD EMISSION FACE) (GAUSS)
BDOT	TIME DERIVATE OF MAGNETIC FIELD, (GUASS/NSEC), PROBABLY TOO NUMERICALLY NOISY TO BE OF USE IN MANY SCL SITUATIONS.
BFALL	EMITTED CURRENT DENSITY FALLS OFF BY FACTOR OF BFALL BY R=R2 IF KOPT(8)=1
BMAX	PEAK AMPLITUDE MAGNETIC FIELD ANYWHERE ALONG CYLINDER SIDE WALL AT THIS TIME (GAUSS)
BST	'BOTTOM, SIDE, TOP' DESIGNATES THE NEXT 3 VARIABLES IN THE MINI-PRINT LIST WHICH ARE THE CURRENTS STRIKING THE BOTTOM, SIDE, AND TOP OF THE CYLINDER, RESPECTIVELY, DIVIDED BY THE PEAK EMISSION CURRENT FROM THE FORWARD FACE. USUALLY REFERRED TO AS FRACTIONAL TRANSMISSIONS. ALSO PRINTED OUT LABELED FJBOT, FJSIDE, FJTOP. THE THREE VALUES SHOULD ADD TO THE VALUE FOR SUMFJ DEFINED BELOW. (DIMENSIONLESS)
CHARGE	PRIMARY ELECTRON CHARGE IN EACH ZONE (COUL). ALSO USED AS CHARGE ON EACH EMITTED PARTICLE IN TIME STEP PRINT OR IN PARTICLE DESCRIPTION PRINT. Q/M SAME AS FOR ELECTRON (COUL)
CHARGE DENSITY	PRIMARY ELECTRON CHARGE DENSITY (COUL/M3)
CNVRG	WHEN SUCCESSIVE TERMS BECOME LESS THAN CNVRG * TOTAL SUM OF TERMS UP TO THAT TERM, TERMINATE SERIES FOR GREEN'S FUNCTION. (DIMENSIONLESS) QUASI-STATIC ONLY
CYCLE	PARTICLE TIME STEP NUMBER
DDTF	APPROX. TIME INCREMENT FOR PATHES OF PARTICLES IN PICTURES. (SEE DTF) EQUALS DTF/NPLOT
DELT	TIME STEP (NANOSECONDS)
DELTSC	TIME STEP IN SECONDS (SEC)
DELZ(1-NZM1)	DELZ(I)=Z(I+1)-Z(I), I=1 TO NZ (CM)
DR(1-NRM1)	DR(I)=R(I+1)-R(I), I=1 TO NRM1 (CM)
DRANG	INJECT CHARGE AT DRANG INTERVALS IN R ACROSS TOP OF CYL.(CM)
DSORS	DISTANCE OF SOURCE FROM CYLINDER END (CM)
DT	ELAPSED EXECUTION TIME SINCE LAST CALL TO GET TOTAL EXECUTION TIME (MINUTES)
DTF	FOLLOW PARTS FROM TOP OF CYL. FOR DTF NANOSECONDS

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Table 4 (cont.)

DTN	LIGHT TIME STEP FROM T(N+1/2) TO T(N+3/2), SEE DTN2,(SEC)
DTN2	LIGHT TIME STEP FROM T(N) TO T(N+1), T(1)=0., SEE DTN,(SEC)
DTSTEP(1-NTSTEP)	SEE TSTEP
DXICRT	INTERPOLATE TO FIND FIELDS FOR ABS((Z-Z0)/L),LT,DXICRIT FOR METHOD=1, ABS((R-R0)/A) ,LT, DXICRT FOR METHOD=3 IF IOPT(15)=0,
EBAR	AVERAGE ENERGY OF THE PRIMARY ELECTRON SPECTRUM INJECTED INTO THE CYL, (MEV)
EBARPT	ENERGY OF BIN WITH LARGEST NUMBER OF PRIMARY ELECTRONS BEING EMITTED AT THIS TIME FROM FORWARD FACE, (MEV)
EBART	EMISSION ELECTRON SPECTRUM AVERAGE ENERGY AT FORWARD FACE AT THIS TIME, (MEV)
EFR1	RADIAL E-FIELD SEEN BY FOLLOWED PART, AT GIVEN TIME (V/M)
EFZ1	AXIAL E-FIELD SEEN BY FOLLOWED PART, AT GIVEN TIME (V/M)
ELN	ELN(1)-ELN(NSPD) ARE THE NUMBER/AREA OF ELECTRONS AT ENERGIES ENRG(1)-ENRG(NSPD) AT ANGLES PLUS AND MINUS ANG, AT RADIAL POSITION, RANG(1)- RANG(NEPTS) (NUMBER/CM**2) (TOTAL NUMBER/CM**2 FOR A GIVEN ENERGY PULSE)
EMISSION POINT	Z POSITION OF EMITTED ELECTRONS (CM)
EMQ	TOTAL CHARGE EMITTED INTO THE CYL, AT A GIVEN RADIUS AND ANGLE DURING THE ENTIRE PULSE, (COUL)
ENERGY	INITIAL ELECTRON ENERGY (MEV),
ENRG	ELECTRON ENERGIES (MEV)
EPS0	EPSILON ZERO (EMISSIVITY OF VACUUM) 8,854E-12 FARAD/M FARAD = COUL/VOLT
EQ	SAME AS I EMITTED
ER	RADIAL ELECTRIC FIELD (VOLT/M)
ERMIN	PEAK AMPLITUDE RADIAL ELECTRIC FIELD ANYWHERE ALONG CYLINDER SIDE WALL AT THIS TIME (VOLT/M)
EVP	Z VELOCITY OF EMITTED PARTICLES (M/SEC)
EVR	RADIAL SPEED OF EMITTED PARTICLES (M/SEC)
EZ	AXIAL ELECTRIC FIELD (VOLT/M)
EZBAK	AXIAL ELECTRIC FIELD ON AXIS AT FORWARD EMISSON FACE(VOLT/M)
EZMAX	AXIAL ELECTRIC FIELD ON AXIS AT TOP FACE (AWAY FROM FORWARD EMISSION FACE) (VOLT/M)
FCNSRV	FRACTIONAL NON-CONSERVATION OF ENERGY, (0 FOR COMPLETE CONSERVATION) (DIMENSIONLESS)
FCOLB	LIKE FCOLT ONLY FOR BOTTOM
FCOLT	CALCULATE FRAC TRANS THRU TOP FOR R ,LT, AND ,GT, FCOLT*R2
FINJEK	EMIT ELECTRONS BETWEEN R=0 AND R=FINJEK * R2
FJBOT	SEE BST
FJSIDE	SEE BST
FJTOP	SEE BST

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Table 4 (cont.)

FQBOT	FRACTION OF TOTAL PRIMARY ELECTRON CHARGE WHICH HAS STRUCK CYLINDER BOTTOM FACE UP TO THIS TIME (DIMENSIONLESS)
FQSIDE	FRACTION OF TOTAL PRIMARY ELECTRON CHARGE WHICH HAS STRUCK CYLINDER SIDE WALL UP TO THIS TIME (DIMENSIONLESS)
FQTOP	FRACTION OF TOTAL PRIMARY ELECTRON CHARGE WHICH HAS STRUCK CYLINDER TOP FACE UP TO THIS TIME (DIMENSIONLESS).
FT	RELATIVE EMISSION CURRENT PULSE HEIGTH AT PRESENT TIME (NORMALIZED TO PEAK VALUE OF 1.) FROM THE FORWARD EMISSION FACE.
FTBOT	FRACTION OF ENERGY INJECTED UP TO THIS TIME WHICH HAS LEFT THRU TOP. (DIMENSIONLESS)
FTSIDE	LIKE FTBOT BUT FOR SIDE
FTTOP	LIKE FTBOT BUT FOR TOP
FWFLD	FRACTION OF TOTAL ENERGY INSIDE CYL. WHICH IS IN FIELDS (DIMENSIONLESS)
FWFLDB	FRACTION OF FIELD ENERGY IN B-FIELD (DIMENSIONLESS)
FWFLDE	FRACTION OF FIELD ENERGY IN E-FIELD (DIMENSIONLESS)
FWIN	FRACTION OF TOTAL ENERGY INJECTED UP TO THIS TIME WHICH IS INSIDE THE CYL. AT THIS TIME. (DIMENSIONLESS)
GR,GZ	RADIAL AND AXIAL FIELDS DUE TO ANNULI OR RINGS OF UNIT CHARGE DEPENDING ON IOPT(15) (STAT-VOLT/CM/STAT-COUL = 9.E+13 VOLT/M/COUL)
IANGRD	FLAG FOR ANG. DIST. SET FROM NANG VALUE 1 ANG. DIST. ON CARDS 0 COS. ANG. DIST -1 ISOTROP. ANG. DIST
H-PHI	MAGNETIC FIELD (AMP/M)
I	EMISSION INDEX
I EMITTED	TOTAL PRIMARY ELECTRON CURRENT EMITTED AT THIS TIME INCLUDES BOTH EMISSION FACES. (AMPS)
IBOT	TOTAL PRIMARY ELECTRON CURRENT STRIKING CYLINDER BOTTOM AT THIS TIME (AMP)
IBOTIN	TOTAL PRIMARY ELECTRON CURRENT STRIKING BOTTOM FACE OF CYLINDER AT RADIUS LESS THAN FCOLB * CYLINDER RADIUS. FCOLB SET AT BEGINNING OF SUBROUTINE TDIMRZ. CURRENTLY EQUALS .67. (AMPS)
ICHECK	CHECK CONVERGENCE OF SERIES EVERY ICHECK TERMS (SEE IPRINT) IF ICHECK INPUT AS NEGATIVE, CHECK CONVERGENCE OF SUMS BY SUMMING IN REVERSED ORDER. (IOPT(3))
IDL	INCREMENT IN THE INDEX OF THE PARTICLES WHICH WILL BE FOLLOWED. THERE WILL BE NSPD*NEPTS*2*NANG PARTICLES EMITTED EACH TIME STEP WITH ANGLE VARYING FIRST,THEN RADIUS OF EMISSION, THEN ENERGY. SEE KOPT(2)
IDT	INDEX INCREMENT IN TIME FOR STORING FRACTIONAL TRANSMISSIONS AND POTENTIAL VS. TIME (SET TO NT/NJDT + 1)
IDYN	0 QUASI-STATIC GREENS FCN METHOD 1 DYNAMIC MAX.EQ. METHOD
IFIN	1 IF .LT. 10 SEC XQT TIME REMAIN OR IF ON LAST TIME STEP 0 OTHERWISE
INJEK	TOTAL NUMBER OF PARTICLES INJECTED INTO CYLINDER UP TO THIS TIME

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Table 4 (cont.)

IOPT(02)	SET EQUAL TO IPRINT
IOPT(03)	SET EQUAL TO ICHECK
IOPT(04)	PLOT SUMS IN SERIES EXPANSION VS. N FOR SINGLE SUM SOLS. FOR EVERY IOPT(4) IR AND IZ VALUES
IOPT(05)	PRINT OUT EVERY FCN FOR EACH N FOR SINGLE SUM SERIES FOR EVERY IOPT(5) IR AND IZ VALUES (SEE IOPT(4)) .LT. 0 PRINT ONLY SUM VS N FOR EVERY IABS (IOPT(5)) IR,IZ
IOPT(06)	.GT. 0 READ IN IOPT(6) (Z0,R0) PAIRS (MUST BE VALUES INCLUDED AS FIELD PTS.) AND CALC FIELDS FOR THESE (Z0,R0) ONLY
IOPT(07)	PLOT EZ,ER VS Z AND R FOR EVERY IOPT(7) Z0,R0 PAIRS PUTTING IOPT(8) CURVES ON EACH GRAPH (IF IOPT(7).GT.0)
IOPT(08)	PUT IOPT(8) CURVES ON EACH GRAPH IF IOPT(7).GT. 0 (MAX OF 4)
IOPT(09)	.GT.0 MAP ER,EZ INTO 33 INTERVALS (3-D PLOT) .LT.0 MAP ER,EZ, MAX NO OF ITERATIONS INTO 33 INTERVALS (3-D PLOT)
IOPT(10)	.GT. 0 TAKE DIVERGENCE OF E FIELD EVERYWHERE AND PRINT OUT FOR EACH Z0,R0 USING SUBROUTINE DIVERG (FOR INDIVIDUAL RINGS)
IOPT(11)	.GT. 0 PRINT OUT ER,EZ AS FCNS OF R,Z FOR EVERY IOPT(11) R0,Z0 POINTS
IOPT(12)	.GT. 0 INTEGRATE GREENS FUNCTIONS FOR FIELDS OVER CHARGE DISTRIBUTION WHICH IS SPECIFIED IN ETOTAL FOR DEBUG PURPOSES ONLY
IOPT(13)	.NE. 0 CALL CHEKE TO CALC SUMS FOR ER(TOTAL) AND EZ(TOTAL) WITH CONSTANT RHO ASSUMED .LT. 0 TAKE DIVERGENCE OF FIELDS CALCED WITH CHEKE .LT. -1 EXIT AFTER CALL CHEKE
IOPT(14)	.GT. 0 PRINT OUT GREENS FCNS FOR ER,EZ FOR EACH R,Z,R0,Z0
IOPT(15)	0 CALC GREENS FCNS FOR INFINTESIMAL RINGS OF CHARGE 1 CALC FIELDS DUE TO FINITE VOLUME ELEMENT OF CHARGE FOR GREENS FCNS, IE SMEAR OUT THE CHARGE OVER A VOLUME ELEMENT, GOOD FOR METHOD=3 ONLY
IOPT(16)	.GT. 0 FAST DRUM UNIT FOR GREENS FCN
IOPT(17)	.GT. 0 READ RESTART TAPE ON UNIT IOPT(17)
IOPT(18)	.GT. 0 WRITE RESTART TAPE ON UNIT IOPT(18)
IPLOT	2 PRINT PARTICLE POSITIONS AND VELOCITIES VS TIME FOR SELECTED PARTICLES , ALSO PLOT 1 PLOT PARTICLE PATHES
IPRINT	IF .GT. 0, INTERMEDIATE PRINT OF SERIES EVERY ICHECK TERMS IF .GT. -1, PRINT NO. OF TERMS USED FOR EACH R, Z CALCED. (IOPT(2))
IPSTOP	NUMBER OF PARTICLES TRANSFERRED TO CONTINUUM PLASMA DURING THIS TIME STEP
IRMAX	PARAMETER. NO. OF RADIAL ZONES + 1
IROMAX	PARAMETER. NO. OF RADIAL ZONES.
ISIDE	TOTAL PRIMARY ELECTRON CURRENT STRIKING CYLINDER SIDE AT THIS TIME (AMP)
ISTOPT	CUMULATIVE NUMBER OF PARTICLES TRANSFERRED TO PLASMA UP TO THIS TIME.
ISTORE	TDIM 0 DONT STORE PART POSITIONS,ETC THIS TIME STEP 1 STORE PART POSITIONS,ETC THIS TIME STEP

Table 4 (cont.)

ITIME	PARTICLE TIME STEP NUMBER
ITOP	TOTAL PRIMARY ELECTRON CURRENT STRIKING CYLINDER TOP AT THIS TIME (AMP)
ITOPIN	SAME AS IBOTIN ONLY FOR CYLINDER TOP (FACE AWAY FROM FORWARD EMISSION FACE) (AMP)
IZMAX	PARAMETER, NO. OF AXIAL ZONES + 1
J	INDEX
J EMITTED	TOTAL CURRENT AT TIME,T, ENTERING CYL. (AMP) SEE EQ
JBOT	IBOT DIVIDED BY BOTTOM FACE AREA, GIVES AVERAGE PRIMARY ELECTRON CURRENT DENSITY INCIDENT ON BOTTOM FACE, (AMP/CM2)
JDT	RUNNING INCREMENT IN TIME FOR STORING FRACTIONAL TRANSMISSIONS AND POTENTIAL VS. TIME
JNOW	EMISSION ELECTRON CURRENT DENSITY AT AXIS OF FORWARD EMISSION FACE AT THIS TIME (AMP/CM2)
JOUTB	SAME AS JOUTT BUT FOR BOTTOM FACE
JOUTS	SAME AS JOUTT BUT FOR SIDE WALL.
JOUTT	PRIMARY ELECTRON CURRENT DENSITY STRIKING CYLINDER TOP SURFACE IN EACH RADIAL ZONE, (AMP/CM2)
JPEAK	PEAK EMISSION ELECTRON CURRENT DENSITY AT AXIS OF FORWARD EMISSION FACE (AMP/CM2)
JR	PRIMARY ELECTRON RADIAL CURRENT DENSITY (AMP/M2)
JR CONDUCTIVITY	RADIAL CURRENT DENSITY IN EACH ZONE DUE TO SECONDARY ELECTRON MIGRATION, (AMP/M2)
JSIDE	ISIDE DIVIDED BY CYLINDER SIDE WALL AREA, GIVES AVERAGE PRIMARY ELECTRON CURRENT DENSITY INCIDENT ON CYLINDER SIDE WALL (AMP/CM2)
JTOP	ITOP DIVIDED BY CYLINDER TOP FACE AREA, GIVES AVERAGE PRIMARY ELECTRON CURRENT DENSITY INCIDENT ON TOP FACE OF CYLINDER (AMP/CM2).
JZ	PRIMARY ELECTRON AXIAL CURRENT DENSITY (AMP/M2)
JZ CONDUCTIVITY	AXIAL CURRENT DENSITY IN EACH ZONE DUE TO SECONDARY ELECTRON MIGRATION (AMP/M2)
KPFLG	PRINT FLAG USED IN TDIM, 0 NOT A PRINT CYCLE, 1 PRINT CYCLE
KPULSE	FLAG USED TO INDICATE MAX. STORAGE FOR NO. OF PARTS. HAS BEEN REACHED. 0 TURN PULSE OFF. 1 LEAVE PULSE ON.
KR	SURFACE CURRENT DENSITY IN RADIAL DIRECTION (AMP/M)
KZ	SURFACE CURRENT DENSITY IN AXIAL DIRECTION (AMP/M)
L	LENGTH OF CYLINDER L=Z2 (CM)
LE	PARAMETER, MAX. NO. OF PARTICLES WHICH CAN BE INJECTED AT EACH INJECTION TIME, (2*NANG*NEPTS*NSPD,LE,LE)
LL	PARAMETER, MAX. NO. OF PARTICLES CODE CAN FOLLOW.
LOWER WALL CHARGE DENSITY	SURFACE CHARGE DENSITY IN EACH ZONE ON LOWER CYLINDER FACE (COUL/M2)
LPG	PARAMETER, NO. OF AXIAL ZONES + 1
LPHI	PARTICLE INITIAL ANGULAR MOMENTUM IN THE UNFORTUNATE UNITS OF G-CM-M/SEC WHICH MEANS THE NUMBER IS 10**5 HIGHER THE MKS UNIT OF JOULE-SEC.

Table 4 (cont.)

LRATIO(1-NRGP)	MIN. DELTA R IS R2/SUM OF LRATIO(1) THRU LRATIO(NRGP). THEN DELR(I) = LRATIO(I) * MIN. DELTA R
LRG	PARAMETER. NO. OF RADIAL ZONES + 1
LZRAT(1-NPG)	SAME AS LRATIO EXCEPT FOR AXIAL ZONES
MAXNS	MAX. NO. OF TERMS ALLOWED IN EACH SUM IN THE SERIES FOR GREEN'S FUNCTION. SET TO MMAXNS
METHOD	1 IF L/A.GE.1, SINGLE SUM SOL. WITH SINH, COSH FCNS. 2 DOUBLE SUM SOL. WITH ORDINARY BESSEL FCNS. DEBUG OPTION, MUST BE SET IN FORTRAN. 3 IF L/A.LT.1, SINGLE SUM SOL. WITH MODIFIED BESSEL FCNS. -1 DO SINGLE SUM SOLS. FOR METHOD=1 AND 3. DEBUG OPTION, MUST BE SET IN FORTRAN.
MJDT	PARAMETER VARIABLE. EQUALS NJDT
MMAXNS	PARAMETER. NO. OF TERMS ALLOWED IN SERIES FOR GREENS FCN.
NANG	NO. OF ANGLES AT WHICH PARTICLES ARE EMITTED. SEE LE READ IN IN KOPT(10) .GT. 0 CODE READS ANG. DIST ON CARDS WITH NANG BINS .LT. 0 CODE SETS COS ANG. DIST WITH IABS(NANG) BINS. .LT. -100 CODE SET ISOTROP. ANG DIST WITH IABS(NANG) -100 ANGLE BINS
NEPTS	R,Z GEOM. - NO. OF RADII AT WHICH INCOMING ELECTRONS ARE EMITTED FROM THE TOP OF THE CYL. (SEE LE) READ IN IN KOPT(14)
NESKIP	INPUT THE INCIDENT ELECTRON SPECTRUM EVERY NESKIP TIME STEPS (READ IN IN KOPT(4))
NET CHARGE DENSITY	NET CHARGE DENSITY IN EACH ZONE INCLUDING PRIMARY AND SECONDARY ELECTRONS AND IONS. (COUL/M3)
NFOLOW	PARAMETER VARIABLE. NO. OF PARTICLES TO BE FOLLOWED FOR TRAJECTORY PLOT
NINJEK	TOTAL NUMBER OF PARTICLES INJECTED INTO CYLINDER UP TO THIS TIME. PRESENTLY CORRECT ONLY IN FORWARD EMISSION CASES.
NJDT	STORE AND PLOT FRACTIONAL TRANSMISSIONS AND POTENTIALS FOR NJDT TIME VALUES BETWEEN 0 AND TMAX. SEE IDT. SET TO MJDT
NLEAVE	TOTAL NO. OF PARTS. LEAVING CYL. IN TIME INCREMENT, DELT, AT TIME, T.
NLVTOT	TOTAL NUMBER OF PARTICLES STRIKING CYLINDER WALLS UP TO THIS TIME.
NNR	PARAMETER. NO. OF FIELD PTS. IN RADIAL DIRECTION.
NNRO	PARAMETER. NNR
NNZ	PARAMETER. NO. OF FIELD PTS. IN AXIAL DIRECTION.
NNZO	PARAMETER. NNZ
NO. LEAVING	TOTAL NUMBER OF PARTICLES LEAVING SYSTEM BY STRIKING CYLINDER WALLS DURING PREVIOUS TIME STEP. DOES NOT INCLUDE PARTICLES CONVERTED TO PLASMA BACKGROUND IN AIR PRESSURE CASES.
NO.OF ANGLES	NO.OF ANGLES AT WHICH ELECTRONS ARE INJECTED
NO. OF PARTICLES	NUMBER OF PARTICLES BEING FOLLOWED AT PRESENT TIME
NO. OF PARTICLES IN EACH ZONE	NUMBER OF PARTICLES REPRESENTING PRIMARY ELECTRONS IN EACH SPATIAL ZONE. DOES NOT COUNT PARTICLES OUTSIDE CYLINDER BUT WITHIN 1/2 ZONE WHICH ARE BEING FOLLOWED FOR PROPER BOUNDARY TREATMENTS.
NPART	NUMBER OF PARTICLES BEING FOLLOWED THIS TIME STEP. ALSO PRINTED OUT AS LAST NUMBER ON TOP LINE OF THE MINI-PRINT

Table 4 (cont.)

NPG	NO. OF AXIAL ZONES
NPGP1	NPG + 1
NPHI	SEE KOPT(10)
NPLOT	PARAMETER VARIABLE WHICH MUST BE .GE. NO. OF POINTS BEING PLOTTED. I.E. NPLOT .GE. MAX(NR,NZ,MAXNS) IN EFIELD. IN TDIM, NPLOT IS A PARAMETER VARIABLE GIVING THE NO. OF PARTICLE POSITIONS TO BE PLOTTED FOR DTF NANOSECONDS.
NPLOT2	PARAMETER VARIABLE EQUAL TO NPLOT*2
NR	NO. OF FIELD PTS IN RADIAL DIRECTION
NRADI	FLAG USED TO SIGNAL MORE INCOMING ELECTRONS AT ANOTHER ANGLE 0 NO MORE ELECTRONS .NE. 0 MORE ELECTRONS AT ANOTHER ANGLE 10 MONOCHROMATIC BEAM WITH NANG*NEPTS*2 PARTICLES INPUT INTO TOP OF CYL. EACH STEP
NRG	NRGP+1
NRGP	NO. OF RADIAL ZONES
NRGPP1	NRGP+1 EQUALS NRG
NRM1	NR-1
NRO	NO. OF R POSITIONS OF RINGS OF CHARGE BEING CALCED (.GE. 1)
NR1	NUMBER OF PARTICLES REFLECTED THROUGH CYLINDER AXIS THIS TIME STEP
NR2	NUMBER OF PARTICLES WHICH STRUCK CYLINDER SIDE WALL THIS TIME STEP
NSPD	NO. OF ENERGIES IN SPECTRUM OF INCOMING ELECTRONS (SEE LE)
NT	NO. OF TIME STEPS TO BE TAKEN. NT=TMAX/DELT
NTOT	TOTAL NO. OF ELECTRONS ENTERING THRU TOP OF CYL. IN A GIVEN IF ZERO, CALCULATED FROM JPEAK,PULSE AREA, AND CYLINDER AREA. EQUALS TOTAL NO. INJECTED IN WHOLE PULSE INTERNALLY BUT INPUT AS NO./CM**2
NTPULS	NO. OF TIME AND REL. PULSE HEIGHT VALUES USED TO DEFINE EMITTED CURRENT PULSE (KOPT(13))
NTSKIP	PRINT OUT EVERY NTSKIP TIME STEPS READ IN IN KOPT(15)
NTSTEP	NO. OF DIFFERENT TIME STEP SIZES (READ IN IN KOPT(12))
NZ	NO. OF FIELD PTS IN AXIAL DIRECTION
NZM1	NZ - 1
NZO	NO. OF Z POSITIONS OF RINGS OF CHARGE FOR GREEN'S FUNCTION
NZ1	NUMBER OF PARTICLES WHICH STRUCK CYLINDER BOTTOM THIS TIME STEP
NZ2	NUMBER OF PARTICLES WHICH STRUCK CYLINDER TOP THIS TIME STEP
OUTER WALL CHARGE DENSITY	SURFACE CHARGE DENSITY IN EACH ZONE ALONG CYLINDER SIDE WALL (COUL/M2)
PA	AIR PRESSURE IN CYLINDER, ALSO FLAGS QUASI-STATIC CALCULATION IF SET TO -1.E-20 AND PROBLEM MUST BE VACUUM ONLY.
PHI	PARTICLE VELOCITY INITIAL AZIMUTHAL ANGLE. PHI=0 MEANS PARTICLE INITIALLY GOES RADIALLY OUTWARD, PHI=180 MEANS PARTICLE INITIALLY GOES INWARD.

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Table 4 (cont.)

PLASMA OSCILLA- -TION PERIOD	APPROXIMATE EXPRESSION FOR PLASMA OSCILLATIONS BASED ON AVERAGE CHARGE DENSITY IN CYLINDER. SHOULD BE VAGUELY CONSISTENT WITH OBSERVED LOW FREQUENCY RINGING PERIOD IN QUASI-STATIC SITUATIONS (NSEC)
POTENTIAL REL. TO R=A	ELECTRIC POTENTIAL OBTAINED BY INTEGRATING RADIAL ELECTRIC FIELD IN FROM CYLINDER SIDE WALL (VOLTS)
POTENTIAL REL. TO Z=L	ELECTRIC POTENTIAL OBTAINED BY INTEGRATING AXIAL ELECTRIC FIELD DOWN FROM TOP FACE OF CYLINDER (Z=L) (VOLTS)
PRIMARY ELECTRON IONIZATION RATE	RATE AT WHICH PRIMARY ELECTRONS IONIZE THE AIR MOLECULES. (ELECTRONS/M3/SEC)
PULSE(1-NTPULS)	RELATIVE VALUES OF EMISSION CURRENT DENSITY AT TIMES TPULSE(1 THRU NTPULS)
Q	CHARGE ON PARTICLES EMITTED THIS TIME STEP (COUL)
QDIF	FRACTIONAL DIFFERENCE BETWEEN CUMULATIVE EMITTED, AND ABSORBED PRIMARY ELECTRON CHARGES AND THE AMOUNT INSIDE THE CYLINDER ACCORDING TO THE CODE. VALUE SHOULD BE SMALL (LT.1) INDICATING GOOD CONSERVATION OR SOMETHING HAS GONE WRONG WITH THE CALCULATION. SEE NOTE ON QINSYD (DIMENSIONLESS).
QE	ELECTRON CHARGE (COUL)
QINJEK	TOTAL CHARGE EMITTED UP TO THIS TIME FROM BOTH EMISSION SURFACES. (COUL).
QINSYD	TOTAL PRIMARY ELECTRON CHARGE WITHIN THE CYLINDER AT THIS TIME (COUL). DOES NOT COUNT THOSE PARTICLES WHOSE CENTERS ARE OUTSIDE THE CYLINDER BUT WITHIN 1/2 ZONE WHICH ARE FOLLOWED FOR OBTAINING PROPER BOUNDARY VALUES OF CURRENTS.
QLEAVE	TOTAL CHARGE WHICH HAS STRUCK ALL THREE CYLINDER SURFACES UP TO THIS TIME (COUL) INCLUDES THOSE PARTICLES OUTSIDE THE CYLINDER WHICH ARE STILL BEING FOLLOWED TO 1/2 ZONE AWAY FOR PROPER BOUNDARY TREATMENT.
QLEAVP	NOT CALCULATED PROPERLY AT PRESENT.
QOUTB	SAME AS QOUTT BUT FOR BOTTOM FACE.
QOUTS	SAME AS QOUTT BUT FOR SIDE WALL.
QOUTT	TOTAL PRIMARY ELECTRON CHARGE PER UNIT AREA WHICH HAS STRUCK CYLINDER TOP SURFACE IN EACH RADIAL ZONE (COUL/CM2)
QR1	CUMULATIVE AMOUNT OF CHARGE REFLECTED THROUGH CYLINDER AXIS UP TO THIS TIME STEP (COUL)
QR2	CUMULATIVE CHARGE WHICH HAS STRUCK CYLINDER SIDE WALL UP TO THIS TIME (COUL)
QR2P	SAME AS QZ2P BUT FOR CYLINDER SIDE WALL.
QSM	CHARGE/MASS FOR ELECTRON (COUL/GM)
QSTOP	AMOUNT OF CHARGE CONVERTED TO THE PLASMA FORMULATION ELECTRON CHARGE DENSITY DURING THIS TIME STEP (COUL).
QSTOPT	CUMULATIVE AMOUNT OF CHARGE CONVERTED TO THE PLASMA FORMULATION ELECTRON CHARGE DENSITY UP TO THIS TIME (COUL).
QZ1	CUMULATIVE CHARGE WHICH HAS STRUCK CYLINDER BOTTOM UP TO THIS TIME (COUL)
QZ1P	SAME AS QZ2P BUT FOR CYLINDER BOTTOM FACE.
QZ2	CUMULATIVE CHARGE WHICH HAS STRUCK CYLINDER TOP UP TO THIS TIME (COUL)
QZ2P	SUM OF QOUTT (I) TIMES AREA OF RADIAL ZONE I OVER WHOLE FACE. PROVIDES INTERNAL CONSISTENCY CHECK OF CUMULATIVE CHARGE STRIKING TOP SURFACE WHEN COMPARED WITH QZ2. (COUL)

Table 4 (cont.)

R	PARTICLE INITIAL RADIAL POSITION (CM) IN EMISSION CHARACTERISTICS PRINTOUT , ALSO USED FOR RADIAL GRID POINTS IN GREEN'S FCN CALCULATION.
R SPEED	RADIAL SPEED OF EMITTED ELECTRONS (M/SEC)
RADIUS	RADIAL POSITION OF EMITTED ELECTRONS (CM)
RANG(NEPTS)	RANG(1)- RANG(NEPTS) ARE THE RADII FROM WHICH ELECTRONS ARE EMITTED FROM THE TOP OF THE CYL. (EVENLY SPACED) (CM). SEE RINJEK.
RBAR(1-NRM1)	RBAR(I) = .5*(R(I)+R(I+1)) , I=1 TO NRM1 (CM)
RDD	ACCEL IN R DIRECTION (M/SEC**2)
REFQ	REFLECT REFQ OF THE CHARGE STRIKING THE CYL. WALLS
RG	RADIAL ZONE BOUNDARIES (CM)
RGP(1-NRGP)	ZONE CENTER RADII (CM)
RHO	CHARGE DENSITY (COUL/CM**3) RHO(IZ,IR) IS FOR ZONE BOUNDED BY Z(IZ)-Z(IZ+1),R(IR)-R(IR+1)
RHO-E	SECONDARY ELECTRON NUMBER DENSITY (ELECTRONS/M3)
RHO-I	ION NUMBER DENSITY (IONS/M3)
RINJEK	OUTER RADIUS OF AREA OVER WHICH CHARGE IS INJECTED INTO CYL. (CM)
RO(1-NRO)	R COORDS. OF RINGS OF CHARGE IN GREEN'S FCN. (CM)
RPOS	R POSITION OF FOLLOWED PART. AT GIVEN TIME (CM)
R0	FOR IOPT(15)=1, R0 IS INNER R VALUE OF THE FINITE VOLUME ELEMENT OF CHARGE OF THE SOURCE ANNULUS IN THE GREEN'S FCN.
R1	INNER RADIUS OF SMALLEST RADIAL ZONE (CM)
R2	RADIUS OF CYLINDER (CM)
SECONDARY ELECTRON IONIZATION RATE	RATE AT WHICH SECONDARY ELECTRONS IONIZE THE AIR MOLECULES. (ELECTRONS/M3/SEC)
SIDEMT	LIKE BAKEMT ONLY FOR SIDE
SIGMA-R	RADIAL CONDUCTIVITY OF PLASMA IN EACH ZONE (MHO/M)
SIGMA-Z	AXIAL CONDUCTIVITY OF PLASMA IN EACH ZONE (MHO/M)
SPD	SPEED OF EMITTED PARTICLES (M/SEC)
SPEED	SPEED OF EMITTED ELECTRONS (M/SEC)
STEP NO.	PARTICLE TIME STEP NUMBER
SUMFJ	SUM OF THE CURRENTS STRIKING ALL THREE CYLINDER SURFACES AT THIS TIME DIVIDED BY THE PEAK EMISSION CURRENT FROM THE FORWARD FACE. (DIMENSIONLESS)
SUMFQ	APPROXIMATE CHARGE CONSERVATION INDICATOR. SHOULD BE CLOSE TO UNITY. EQUALS SUM OF CHARGES STRIKING CYLINDER BOTTOM, SIDE, AND TOP PLUS CHARGE INSIDE ALL DIVIDED BY TOTAL CHARGE EMITTED UP TO THIS TIME. DOES NOT COUNT CHARGE OUTSIDE CYLINDER BUT WITHIN 1/2 ZONE SO IS USUALLY SLIGHTLY LESS THAN 1. SHOULD ADD TO UNITY WHEN EMISSION PULSE IS OVER AND ALL PRIMARY ELECTRON CHARGE HAS LEFT THE CYLINDER, UNLESS PARTICLES OF CHARGE WERE CONVERTED TO THE BACKGROUND PLASMA. (DIMENSIONLESS)

Table 4 (cont.)

T	TIME (NSEC)
TE	FRACTION OF THE TOTAL EMISSION CURRENT PULSE AREA OCCUPIED BY THE PRESENT EMISSION PULSE HEIGTH AT THE FORWARD FACE TIMES THE PARTICLE TIME STEP, (DIMENSIONLESS)
TEB	SAME AS TE ONLY FOR BACK EMISSION FACE.
TFOLOW	NEXT TIME AT WHICH TO PICK UP PARTS, FOR PLOTTING PATHES (NS)
THETA	PARTICLE VELOCITY INITIAL POLAR ANGLE MEASURED FROM SURFACE NORMAL, (DEGREES)
TIME	TIME (NSEC)
TIME GRID	TIME STEP (NANO-SEC)
TINSYD	TOTAL KINETIC ENERGY OF ELECTRONS INSIDE CYL, (JOUL)
TMAX	MAX TIME (NANO-SEC)
TOTAL CHARGES ON THE SYSTEM	THE FIVE VARIABLES LISTED BELOW PERTAIN TO PRIMARY ELECTRON PARTICLES AND FIELDS ONLY. THE NUMBERS ARE OBTAINED FROM THE CONTINUITY EQUATION AND THEY ALLOW A CHECK ON THE CONSERVATION OF CHARGE IN THE PORTION OF THE CODE WHICH CONVERTS CHARGED PARTICLES TO CURRENTS ON THE SPATIAL GRID, PLASMA CHARGES AND CHARGE MOTION ARE NOT INCLUDED.
INSIDE CYLINDER	TOTAL PRIMARY ELECTRON CHARGE INSIDE CYLINDER (COUL). MINOR INCONSISTENCY BETWEEN THIS VALUE AND QINSYD VARIABLE PROBABLY DUE TO FINITE TIME STOP SIZE USED IN INTEGRATION OF CONTINUITY EQUATION. THIS NUMBER IS OBTAINED FROM SUMMING ARRAY FOR CHARGE DENSITY IN THE MAXWELL'S EQUATION PORTION OF THE CODE, WHEREAS QINSYD IS OBTAINED DIRECTLY FROM PARTICLE STORAGE ARRAYS.
UPPER WALL	NET CHARGE ON CYLINDER TOP FACE (COUL)
LOWER WALL	NET CHARGE ON CYLINDER BOTTOM FACE (COUL)
OUTER WALL	NET CHARGE ON CYLINDER SIDE WALL (COUL)
SYSTEM TOTAL	SUM OF THE CHARGES INSIDE AND ON THE CYLINDER WALLS. SHOULD ADD TO SMALL VALUE INDICATING CHARGE CONSERVATION, (COUL)
TPULSE	TIMES AT WHICH EMISSION CURRENT PULSE IS DEFINED (NSEC)
TSTART	IF READING A DUMP TAPE, RESTART AT TIME .GE. TSTART (CAN BE 0.) SEE IOPT(17) (NS)
TSTEP(1-NTSTEP)	TIME STEP IS DTSTEP(I) BETWEEN TSTEP(I) AND TSTEP(I+1) (NSEC)
UPPER WALL CHARGE DENSITY	SURFACE CHARGE DENSITY IN EACH ZONE ON UPPER CYLINDER FACE (COUL/M2)
VMAG	MAGNITUDE OF INITIAL PARTICLE VELOCITY (M/SEC)
VMAX	LARGEST MAGNITUDE OF THE ELECTRIC POTENTIAL ANYWHERE ALONG THE CYLINDER AXIS AT THIS TIME, (VOLTS)
VPHI	PARTICLE INITIAL AZIMUTHAL VELOCITY (M/SEC)
VR	PARTICLE INITIAL RADIAL VELOCITY (M/SEC)
VR1	RADIAL SPEED OF FOLLOWED PART, AT GIVEN TIME (M/SEC)
VZ1	AXIAL SPEED OF FOLLOWED PART, AT GIVEN TIME (M/SEC)
VZ	PARTICLE INITIAL AXIAL VELOCITY (M/SEC)
WF	ENERGY IN E AND B FIELDS (JOUL)

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Table 4 (cont.)

WINCOR	CORRECT TOTAL ENERGY WHICH SHOULD BE IN CYL. (EQUALS ENERGY INJECTED - ENERGY WHICH HAS LEFT UP TO THIS TIME) (JOUL)
WINSYD	TOTAL KINETIC + FIELD ENERGY INSIDE CYL. (JOUL)
Z	AXIAL ZONE BOUNDARIES (CM) , ALSO, PARTICLE INITIAL AXIAL POSITION (CM) IN EMISSION CHARACTERISTICS PRINT,ALSO GRID POINTS IN GREEN'S FCN
Z SPEED	AXIAL SPEED OF EMITTED ELECTRONS (M/SEC)
ZBAR(1-NZM1)	ZBAR(I) = .5*(Z(I)+Z(I+1)) , I=1 TO NZM1 (CM)
ZBPLT	PLOT MAGNETIC FIELD AT OUTSIDE WALL AT POSITION ZBPLT CM. FROM BOTTOM.
ZDD	ACCEL. IN Z DIRECTION (M/SEC**2)
ZO(1-NZO)	Z COORDS. OF RINGS OF CHARGE IN GREEN'S FCN. (CM)
ZPOS	Z POSITION OF FOLLOWED PART. AT GIVEN TIME (CM)
Z0	FOR IOPT(15)=1, Z0 IS LOWER Z VALUE OF THE FINITE VOLUME ELEMENT OF CHARGE IN THE GREEN'S FCN SOURCE TERM
Z1	Z-POSITION OF BOTTOM OF CYL (CM) CYL.EXTENDS FROM 0 TO L
Z2	Z-POSITION OF TOP OF CYL. (CM) (SEE L)

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